INTERNATIONAL ATOMIC ENERGY AGENCY
Department of Nuclear Safety, Division of Radiation and Waste Safety

Specialists' Meeting on
Protection of the Environment from the Effects of
Ionizing Radiation: International Perspectives
(Reference: 723-J9-SP-1114.2)

IAEA Headquarters, Vienna, 29 August – 1 September 2000

REPORT

This meeting was attended by around 60 participants from 22 Member States and 2 international organizations. The meeting provided an opportunity for both information exchange, regarding appropriate regulatory and research developments, and for detailed discussion of many of the issues that will need to be addressed in developing a system to protect the environment from the effects of ionizing radiation. Such discussions were facilitated by formation of 3 Working Groups dealing with: Ethical Dimensions and Principles; Endpoint Specification, and Quantities, Units and Compliance. The meeting Agenda and the list of issues considered by each of the Working Groups are provided as appendices. Abstracts of papers presented and presentation materials were distributed at the meeting. As a result, this report focuses on the Working Group discussions. The discussions were led by a Working Group Leader and Panel, many of whom also contributed to the preparation of this report.

Working Group Results

Ethical Dimensions and Principles

The first issue addressed by this group was the definition of 'the environment'. The group concluded that, while defined within the framework of national laws and international legal instruments, 'the environment', within the context of the protection of the environment from ionizing radiation, should be considered to include man, biota, abiota, physical surroundings, and their interactions. However, given our understanding of the effects of ionizing radiation, the focus for environmental protection should be the protection of biota.

It was recognized that we have limited knowledge of man's effects on the ecosystem, and since the environment is fragile and capable of being damaged, we need to protect it for a variety of ethical reasons and viewpoints. Factors considered include its intrinsic worth, public interests, and impacts on future generations. In resolving the ethical framework and principles for environmental protection, the importance of stakeholder involvement and approaches to address potential conflicts with the existing system for the protection of man should be recognized.

It was agreed that the objectives of environmental protection should be to minimize unnecessary impacts on the environment and to ensure that biodiversity was maintained and ecosystem function sustained. However, given the lack of knowledge of the complex interactions within the ecosystem, protection may need to be accomplished by focusing on populations within it.

The group concluded that 'harm' can be defined as any change that is antagonistic to these objectives of protection. While recognizing that there may be a need to accept a broad definition of 'harm', within the framework of national laws, the definition should include the following quantitative attributes: the nature of change, the effects on biodiversity and spatial and temporal effects.

The bases for establishing standards and criteria were also considered. It was agreed that a transparent and consistent basis was needed to determine whether the level of environmental protection was adequate. When applicable, criteria should be consistent with, and complementary to, the approach to environmental protection developed for other pollutants and the goals of sustainable development. In developing such criteria, the following issues will need to be considered: (1) whether to include background contributions of radioactivity; (2) whether or not a biological monitoring program should be included as part of the system and, if so, whether the criteria need to be related directly to the outputs of that program; (3) whether effects are measurable or detectable, and to what extent these effects are adverse; (4) the need for criteria to be directly measurable and related to the impacts; and (5) the issue of variability and distribution between human health and environmental impacts. Additional issues discussed were the application of the concept of risk, within the context of environmental protection, particularly as a mechanism for taking account of uncertainties and the relevance of radiation sensitivity and ecological significance in developing a protection framework. Consideration of "site-specific" needs was also discussed. It was further noted that the application of the 'precautionary approach' will need to be addressed further.

Endpoint Specification

The group agreed that endpoints have to be defined that are related, as directly as possible, to radiation harm in the environment. These should be consistent with the principles for environmental protection (covered by the Working Group on Ethical Dimensions and Principles), and to assessments and demonstration of compliance (covered by the Working Group on Quantities, Units and Compliance). The group focused on the following issues:

- Target biological organisation level (what do we want to protect?)
- Endpoints
- Criteria for assessing the relevance of endpoints
- Critical and reference organs/organisms/ecosystems

The group agreed that managerial systems are currently in place, principally for the protection of man, e.g., the ALARA principle and BAT (best available technique), that under many circumstances would, indirectly, protect the environment to some unspecified degree. The group did not further discuss the implications of such managerial principles for identification of endpoints. However, a discussion of optimization strategies and ALARA concepts used for human protection, and their applicability to protection of non-human biota, would be valuable in developing a protection system for the environment and in determining its relationship to or "harmonization" with the protection system for humans.

Target organisational level

The issue of the target level of biological organisation is often discussed in relation to environmental protection. There is a general recognition that the focus for environmental protection is the population. However, the group identified a number of theoretical problems related to identifying populations as the only target organisational level:

- In protecting threatened and endangered species, it is necessary to consider individuals.
- The precautionary approach may dictate that the individual is protected as a means to ensure protection of the population. Furthermore, for a variety of organisms, the distinction between an individual and a population may not be easily made and not entirely meaningful from a biological point of view.
- There are cases where possibly deleterious effects are observed on individuals, which appear to have little, if any, impact on the population. Examples are the occurrence of tumours and the effects of endocrine disrupters; the link to population effects is lacking or inconclusive.
- A large body of existing data on the effects of ionizing radiation on biota is related to individual or lower levels of biological organisation. Information relating such data to population effects is often not available with the result that targeting populations may be difficult from the practical point of view. In order to use such data to establish criteria, further research would be needed to determine how effects observed at the sub-individual and individual organism level are manifested at the individual and population levels, respectively.

In conclusion, trying to define the level of biological organisation of concern for protection may not be the issue. Effects expressed at higher levels of organization are likely to lead to increasing levels of concern (e.g ecosystem > population > organism (individual) > organ > tissue), but the endpoints should be selected on the basis of available information and their relevance, as discussed below.

Endpoints

The group identified a number of endpoints based on information on known biological effects, and grouped these into mechanistic, deterministic and stochastic endpoints. Also environmental concentrations and doses were included among the endpoints, although it was recognized that they were of a different fundamental nature to the others.

- Mechanistic effects: Such endpoints would include, *inter alia*, genetic drift, mutation in certain marker genes, chromosomal aberrations, and induction of certain proteins/enzymes. Metabolic endpoints were discussed but their inclusion was felt to be premature. In general, mechanistic endpoints could provide useful ‘early warnings’, but their relevance to harm as experienced by the organism is disputable or uncertain in most cases.
- Deterministic effects: Such effects include changes in morphology, physiology, biochemistry, fecundity (through life shortening, or through reduced fertility or reproductive ability), population (size, composition, succession), primary production and immune competence. Many of these effects may not be useful as indicators or early warnings, because their observation may indicate that unacceptable impacts on biodiversity or ecosystem function have already occurred. However, a major portion of the scientific knowledge currently available is concerned with deterministic effects, particularly on reproduction endpoints. This information, included in reports published by IAEA, UNSCEAR and the NCRP, has been used to provide useful upper bound dose rate levels that are currently used in many Member States to provide ‘limits’ or benchmarks to assess the impact of radionuclide levels in the environment.

- Stochastic effects: Following discussion, the group agreed that there are probably no stochastic effects, other than the heritable genetic damage and drift discussed above, that are known to be of relevance to non-human biota. Although tumours are observed frequently in some wild animals, e.g. fish, these have largely been attributed to the influence of anthropogenic chemicals.

Environmental concentrations and doses could be related to the primary assessment endpoints, of the type indicated above, and would provide a basis for demonstrating compliance with criteria related to these endpoints, which may be included in regulatory standards .

The group analysed the relevance of the endpoints identified above on the basis of a number of criteria that may be useful for determining their applicability. The criteria considered are:

- the extent to which the endpoint can be used as a measure of sustainability;
- its application as an early warning indicator of possible harm;
- its use to measure ecological significance;
- its measurability (for retrospective assessments);
- its predictability (for prospective assessments);
- its use as a measure of compliance;
- its relevance to societal issues (e.g. local and regional and local economy, culture and public concern);
- its use as a basis for comparison with other environmental hazards;
- its ability to provide a measure of the additive effects of various environmental stressors.

A matrix of the endpoints and criteria, and more detailed descriptions of the criteria, are given in the Appendix.

Critical and reference organs/organisms/ecosystems

The following distinction was made between the terms ‘critical’ and ‘reference’ for use in this group’s discussions:

- ‘Critical’ – those at highest risk of harm, where the identification of a ‘high risk’ situation depends on both scientific knowledge and societal values. The societal aspects of this choice were not considered further by this group;
- ‘Reference’ refers to a standard (see also the results of the Working Group on Dosimetry, Quantities and Units).

It was agreed that identification of a critical organ, organism or ecosystem is situation-dependent and depends on knowledge about exposure situations, ecosystems and endpoints. The following factors to be considered, when identifying critical organs, organisms or ecosystems were identified:

- Radionuclide(s);
- Distribution of radionuclides;
- Sensitivity:
  - of ecosystems (arctic ecosystems; extreme ecosystems; stressed ecosystems; ‘old’ or climax ecosystems),

- of organs,
- of organisms,
- of stage of life cycle;

– Dose rate;

– Life span and time frame.

Dosimetry, Quantities, Units and Compliance

The discussions of this Working Group were largely structured around a list of issues that was distributed at the meeting. Each issue is considered in turn below.

The applicability of "absorbed dose (rate)" as a basis for the assessment

It was agreed that the "absorbed dose (rate)" was an appropriate basis for assessing possible effects arising from the incremental radiation exposure in any environment contaminated with waste radionuclides. This quantity provided the only robust link between the estimated incremental radiation exposures and the substantial information on the biological effects of radiation that has been developed through research programmes over the past century. It was accepted that the quantity "specific energy" might be of use in the low dose (rate) domain where microdosimetric considerations become important, i.e., when the distribution of the absorbed energy divided by the mass of the individual cell or cell nucleus (the presumed primary targets for radiation action) becomes extremely inhomogeneous.

The applicability of generic/reference organism approaches

It was agreed that this approach was appropriate with the caveat that there would be differing degrees of conservatism in a hierarchy that would probably consist of three increasingly realistic levels:

– A screening level that uses conservative assumptions (e.g., the organism is continuously exposed to an infinite media containing maximum observed radionuclide concentrations) for estimating internal and external exposure of the organism. For example, (1) the highest concentration factor (CF) or transfer factor (TF) data for any plant or animal may be used to determine the radionuclide concentrations in a generic reference organism of infinitely large size in which all the α-, β- and γ-energy emitted by the internal sources is completely retained and absorbed; and, (2) the highest values of the distribution coefficients (k_d) may be used to estimate the radionuclide concentrations in sediments (when co-located water and sediment data are absent) to determine the external exposure of a generic organism which is assumed to be infinitely small such that there is no self-shielding of internal organs. This approach does not take account of the differential accumulation of radionuclides in specific organs or tissues of concern, e.g., the gonads, but this generic screening approach would still be expected to be rather conservative overall as a result of the other conservative assumptions indicated above.

– The intermediate, generic/reference organism, approach in which the relevant target organisms, typical of the environment of interest, are selected on the basis of information concerning:

- their radioecological sensitivity (habitat preference and behaviour in relation to the developing radionuclide distributions; and, capacity to accumulate radionuclides into the whole body and differentially into organs and tissues);
- their radiosensitivity (including variations between species - poikilotherms versus homeotherms, and between tissues and organs; and, variations between stages in the life-cycle - gamete versus embryo versus adult); and,
- their ecological sensitivity in terms of their role in the local biological community.

The application of these criteria would tend to result in the selection of typical organisms from the main trophic levels and identification of the relevant targets for dosimetry. The International Union of Radioecology (IUR) is to undertake the development of a database of information on the differential accumulation of radionuclides in tissues/organs (especially the gonads). It is recognized that such a database will have many gaps and that stable element data could also be relevant.

– A full site-specific assessment, i.e., with realistic dosimetry models for the organisms of interest together with site-specific input parameters relating to the radionuclide behaviour and distributions. This may involve the collection and analysis of environmental media and biota to obtain this parameter data and calculate a dose.

It was recognized that the more sophisticated approaches to radiation dosimetry and modelling may be challenged by the lack of radioecological data on the distribution of radionuclides in the wide range of species in many environments. In such situations, scoping or general screening assessments could also be undertaken, in addition to the more detailed modelling approach, both to simplify the assessment and to provide an order of magnitude check on assessment results.

At present, the dosimetry models almost exclusively assume equilibrium conditions, i.e., equilibrium values for the CF/TF/k_d etc. This assumption would be appropriate, more or less, for the routine discharges from an authorized site, or for the future releases from a waste repository. It would not be relevant for a predictive assessment of the possible near-term consequences of an accident situation where there is a need to model the dynamic processes. Such assessments would be dependent on the availability of relevant input parameters, particularly the rate constants for environmental processes. It was also noted that radioecological studies had indicated that in some systems, e.g., the forests, the presence of long-lived organisms leads to long biological and ecological half-times for some radionuclides, i.e., the system is unlikely to be at equilibrium and any assessment would need to be based on a very careful choice of parameters.

A variety of models continue to be developed along these lines. The U.S. Department of Energy (USDOE) has developed a generic reference organism screening model (contained in their ‘Graded Approach’ Methodology) and generic/reference organism models are being developed as part of the FASSET programme. It was agreed that these approaches are, more or less, complimentary and that they could provide a basis for an agreed methodology within an international framework. To this end the participants in the USDOE and FASSET programmes agreed to coordinate with one another, to explore ways of harmonizing the two approaches and share lessons learned as the development of these approaches continues.

The treatment of “RBE”

The problem arises because it can be foreseen that both stochastic and a variety of deterministic effects, with differing “RBE” values from laboratory studies, are likely to be of concern in a contaminated environment. It is also apparent that the appropriate value of the “RBE” might depend on the dose rate. In view of these uncertainties, it was agreed that, in the

interests of transparency, the absorbed dose (rate) for the low LET (β-particles and γ-rays) and high LET (α-particles) radiations should be estimated and reported separately. In each case the correct quantity and unit remain the absorbed dose (rate) and the Gy (h^{-1}), respectively. This approach also has the merit that it can accommodate whatever proposals might be made in the future to aggregate the absorbed doses from different types of radiation to obtain some single measure of "dose (rate)" for the purpose of assessing harm in a contaminated environment.

It was accepted that the quantity "equivalent dose (rate)" and the "Sv (h^{-1})" unit would not be employed in the context of assessing the aggregate radiation exposure of the flora and fauna. There remains, however, the requirement to make such assessments. It was suggested that the quantity "(radiation?) weighted absorbed dose" would be a possible interim alternative, i.e.,

$$\text{(Radiation) Weighted Absorbed Dose (Rate)} = \text{Low LET Absorbed Dose (Rate)} + W_r \times \text{High LET Absorbed Dose (Rate)}$$

where the W_r is the radiation weighting factor appropriate to the organism, effects endpoint and dose rate. Canada offered to take the lead in an IUR group to review the available RBE data and to recommend the value(s) for W_r. It is possible, but probably unlikely, that a single value of W_r could emerge. If multiple values of W_r have to be used, then any estimate of the aggregate Weighted Absorbed Dose (Rate) would have to have an accompanying statement of its domain of applicability. Given the fluidity of this field at the present time, it is probably inappropriate to give a special name to the unit for the quantity (but following the historical precedent of using acronyms (the rep and rem), the "wad" was suggested!).

The relevance of environmental transport models developed for human radiation exposure assessment

It was concluded that these would be applicable up to a certain, possibly variable, point that would depend on the specific context. The point would probably be at, or close to, the estimation of radionuclide concentrations in air, soil, water and sediment, or the estimation of the deposition rate. At this point there would be divergence into either transfer along the human foodchain, or the accumulation into generic/reference (or site specific) organisms; the assessment of external exposure would also involve different dosimetry models for humans and the flora and fauna. It was recognized that the air transport pathway may require particular attention to develop appropriate interception, deposition and uptake data for forest systems (and possibly also for the high altitude alpine environments).

The basis for criteria for demonstrating – radiation dose rate vs. radionuclide concentrations

This issue generated the most intense discussion. It was finally agreed that the protection of the biota had to be discussed in terms of radiation dose rate and that limiting this quantity was the appropriate basis for limiting the harm to the biota to some defined and acceptable degree. Thus, there is not necessarily a one-to-one correspondence between the acceptable degree of radiation effect, produced by a defined dose rate, in any given organism and the radionuclide concentration(s) in its environment. The limiting dose rate for any combination of organism and environment may, however, be re-interpreted in terms of the radionuclide concentration(s) in relevant environmental media, e.g., concentrations in air, water, soil or sediment, or as a deposition density onto soil. A different approach mentioned was that specifying limiting concentrations or deposition densities as environmental quality standards with the objective of providing for the protection of the environment, i.e., a wider objective than simply the protection of the flora and fauna.

It was further suggested that the standard (or limit) be set in terms of a probability distribution that captures the uncertainty of the underlying data from:

- the transport models: radionuclide release → environmental concentrations;
- the dosimetry models: environmental concentrations → radiation dose rate; and,
- the dose response relationships: radiation dose rate → radiation effects.

This approach would allow the probability, or risk, of a given degree of harm to be assessed. This approach will be investigated in the EC-funded FASSET project.

Remaining issues

The remaining points or issues received limited attention. However, it may be concluded that:

- Both time and spatial averaging with regard to the distribution of radionuclides in the environment and the movement of organisms into and out of these contaminated areas will need to be considered in evaluating and interpreting doses and overall impacts to biota.
- One particular definition of a population of organisms has been used in the past, and many others are available. This problem remains to be investigated.
- For the purpose of time-averaging, the life-time of the limiting organism(s) is probably appropriate, but this should be investigated.
- It is very possible that the existing environmental risk assessment methodologies are unrealistically quantitative. This is particularly so in view of the restricted data bases serving the provide the input parameter values for the various models.

The future

The EU-funded EPIC and FASSET projects, both directed towards developing frameworks for environmental protection, should commence in October 2000.

The USDOE's graded approach for evaluating radiation doses to biota is currently available for interim use. USDOE is continuing to refine its screening methodology,and is moving its RAD-BCG Calculator program into a more sophisticated RESRAD-based computer code.

The IUR is intending to establish a relevant working group on transport and dosimetry models (among others that will deal with principles and ethics and radiation effects). The work of this group will include the development of a database of values for concentration factors, transfer factors, kd, etc., and the discussion of the relevant RBE data and the definition of W_r values.

Cooperation between these groups and IAEA initiatives is planned.

Conclusions and Recommendations of the Meeting

This meeting represented a significant advance in the development of an approach for protection of the environment from the effects of ionizing radiation. The meeting participants were able to agree on the overall objectives of environmental protection, the meaning of harm in the context of environmental protection, and the basis for approaches for assessment and compliance. Detailed agreements are summarised below:

- The objectives of environmental protection are to minimize unnecessary impacts on the environment and to ensure that biodiversity was maintained and ecosystem function sustained. 'Harm' was defined as any change that is antagonistic to these objectives. As such, quantitative attributes of 'harm' should be developed that take into account the nature of change, the effects on biodiversity and spatial and temporal effects. Standards

and criteria should be developed which provide a transparent basis for determining whether environmental protection is adequate.

- Protection of the population is generally the main focus for environmental protection, recognizing that the overall objective is to protect the ecosystem or environment. However, effects at the population or higher levels of organization are the result of effects on the individual. Thus, it may be reasonable to consider population and individual effects as two measures of protection. A matrix of endpoint types and attributes was developed that will provide a valuable basis for further development. Further research is required to relate the effects of ionizing radiation at the sub-individual and individual level to the possible consequential effects at a population level.

- Absorbed dose was suggested the correct measure of impact. Environmental concentrations, while valuable as secondary measurable quantities, do not allow the relative impacts of different radionuclides to be taken into account. The development of generic or reference organisms, for dosimetry purposes, was supported. It was stressed that the level of conservatism implied by the models should relate to the level of analysis.

- It would be helpful for there to be coordination of the further development of the assessment models that have been developed under various programs by several agencies (e.g, the USDOE and the FASSET program of the EC). This should provide a basis for an internationally agreed assessment methodology.

- Priority should be given to building on the discussion document IAEA-TECDOC 1091 in a systematic manner to develop an international system of protection for the environment. The IAEA was urged to progress this work further by facilitating information exchange and to work towards developing a Safety Guide on environmental protection of the environment. IAEA should also provide a focus for co-operation with international organizations such as ICRP and IUR which also have work programmes in this area.

The future priorities were summarised as follows:

Generally important	**Important for the Agency**
Co-operation	The Agency could be a focal point for information exchange and co-ordination
A system for environmental protection is needed but we should avoid parallel systems and build to the extent possible on existing systems for environmental and health protection	Through information exchange, the Agency may facilitate development of a system and make sure that there is minimal duplication of work
Research is needed, in general concerning dose-effect and dose-response relationships, and more specifically on: – Internal radionuclide deposition – Appropriate RBEs – Ecological significance of genetic damage – Effects of mixed contaminants	The Agency may update data on endpoints and the relevant scientific source (beyond the 1996 UNSCEAR Report)
A Safety Guide should be developed	The Agency could take this initiative and carry the work through

ANNEXES

1. **Agenda**

2. **Issues considered by the Working Groups**

3. **Table summarising endpoints their possible relevance**

INTERNATIONAL ATOMIC ENERGY AGENCY
Department of Nuclear Safety, Division of Radiation and Waste Safety

Specialists' Meeting on
Protection of the Environment from the Effects of
Ionizing Radiation: International Perspectives
(Reference: 723-J9-SP-1114.2)

IAEA Headquarters, Vienna, 29 August – 1 September 2000

Conference Room I

PROVISIONAL AGENDA

Tuesday, 29 August 2000

09:30–10:30	Opening of the meeting	Mr. A.J. González, IAEA
	Welcome and Introduction to the Chairman	
	Provisional Agenda for the meeting	**Mr. R. Osborne, Canada**
	International and Regional Developments:	**Mr. D. Cancio, Spain**
	IAEA Perspectives	Mr. G. Linsley, IAEA
10:30–11:00	*Coffee break*	
11:00–12:30	**International and Regional Developments (cont.):**	
	• ICRP	Mr. R. Alexakhin, ICRP
	• IUR	Mr. P. Strand, IUR
	• EC	Mr. G. Hunter and Mr. E. Schulte, EC
	• Establishing a Protection Framework – The FASSET Programme	Mr. C-M. Larsson, Sweden
	• The EPIC Programme	Mr. J. Brown, Norway
12:30–14:00	*Lunch break*	
14:00–15:30	**National Developments:**	**Mr. R. Alexakhin, ICRP**
	• Canada	Ms. P. Thompson, Canada
	• China	Mr. H. Liu, China
	• Finland	Ms. K-L. Sjoeblom, Finland
	• Germany	Mr. E. Wirth, Germany
	• Norway	Mr. J. Brown, Norway
15:30–16:00	*Coffee break*	
16:00–17:30	**National Developments (cont.):**	
	• Russian Federation	Ms. E. Uspenskaya, Russia
	• Spain	Mr. D. Cancio, Spain
	• Sweden	Mr. C-M. Larsson, Sweden
	• United Kingdom	Mr. C. Williams, UK
	• United States of America	Mr. S. Domotor, Ms. M. Clark and Ms. C. Abrams, USA
17:30	*Cocktail party – VIC Restaurant*	

Wednesday, 30 August 2000

09:00–10:30	**Case Studies:**	**Mr. S. Domotor, USA**
	• Impact of Uranium Mining on the Aquatic Environment	Mr. A. Zapantis, Australia
	• Implications of Alaskan Studies	Ms. M. Clark, USA
	• An Assessment of Radiological Effects on the Natural Environment, based on a generic performance assessment for a deep geological repository for intermediate level waste in the UK	Mr. S. Jones, UK
10:30–11:00	*Coffee break*	
11:00–12:30	**Principles of Protection:**	**Mr. D. Woodhead, UK**
	• Ethical Issues	Ms. D. Oughton, IUR
	• IAEA Consultants Meeting Conclusions	Mr. R. Osborne, Canada
	• Review by the Canadian Advisory Committee Working Group on protection of non-human biota from ionizing radiation	Mr. B. Tracy, Canada
12:30–14:00	*Lunch break*	
14:00–15:30	**Endpoints of Concern:**	**Mr. C-M. Larsson, Sweden**
	• Review of Comparative Radiobiology of Wild Animal Species	Ms. C. Mothersill, Ireland
	• Determining Significant Endpoints for Ecological Risk Analysis	Mr. T. Hinton, USA
	• Ecological Approach to Establishing Dose Criteria to Biota	Ms. T. Sazykina, Russia
15:30–16:00	*Coffee break*	
16:00–17:00	**Dosimetry, Quantities and Units and Compliance:**	**Mr. P. Strand, IUR**
	• Reference Dose Models for Fauna and Flora	Mr. D. Woodhead, UK
	• DOE's dose models and graded approach for evaluating compliance with biota dose limits: process overview and case study employing screening models and the RAD-BCG Calculator	Mr. S. Domotor and Ms. K. Higley, USA
17:00–17:30	Introduction to Working Groups	**Mr. R. Osborne, Canada**

Thursday, 31 August 2000

09:30–10:30	Summary of Relevant Issues by Working Group Chairman Discussion of Working Group topics	**Mr. R. Osborne, Canada**
10:30–11:00	*Coffee break*	
11:00–17:30	Working Groups:	
	Ethical Dimensions and Principles	**Ms. M. Clark, USA**
	Endpoint Specification	**Mr. C-M. Larsson, Sweden**
	Quantities, Units and Compliance	**Mr. P. Strand, Norway**

Friday, 1 September 2000

09:00–10:00	Reports by Working Group Leaders Including proposals for future priorities	**Mr. R. Osborne, Canada**
10:00–10:30	*Coffee break*	
10:30–13:00	Discussion of Working Group Results and Identification of Future Work Priorities	

INTERNATIONAL ATOMIC ENERGY AGENCY
Department of Nuclear Safety, Division of Radiation and Waste Safety

Specialists' Meeting on
Protection of the Environment from the Effects of
Ionizing Radiation: International Perspectives
(Reference: 723-J9-SP-1114.2)

Ethical Dimensions and Principles Working Group

Panel: Mary Clark (Leader), Alex Zapantis, Bliss Tracy, Deborah Oughton

Examples of issues to be addressed:

Why do we need to protect the environment ?

What are we trying to protect ?

What would be the basis for establishing criteria ?

What role do radiation sensitivity and ecological significance play in this process ?

What do we mean by 'harm' — is any change necessarily harmful ?

Does the concept of 'risk' have any relevance in an environmental context ?

Legal implications

- the implications of biological diversity and sustainable development
- dealing with uncertainties — precautionary approach

Stakeholder involvement

- how is this best achieved ?
- how can account be taken of different value systems, e.g. native studies in Alaska;

Methods for taking account of approaches developed for assessing the environmental effects of chemicals;

Implications of the system for protection of man

Hoiw do we deal with 'double standards' (i.e. that people may not accept implications of their desires) ?

Future priorities ?

INTERNATIONAL ATOMIC ENERGY AGENCY
Department of Nuclear Safety, Division of Radiation and Waste Safety

Specialists' Meeting on
Protection of the Environment from the Effects of
Ionizing Radiation: International Perspectives
(Reference: 723-J9-SP-1114.2)

Endpoint Specification Working Group

Panel: Carl-Magnus Larsson (Leader), Patsy Thompson, Tom Hinton, Carmel Mothersill

Examples of issues to be addressed:

In practical terms, how can 'harm' be measured ?

- on what level of the ecosystem hierarchy is 'harm' measured - cellular, individual, population, species or ecosystem ?
- are the only changes of relevance those which affect, or could affect, the population?
- are sentinel or reference biota appropriate vehicles for measuring the impact of radiation ?

What information is available to relate exposure and harm ?

What characterises the radiation effects ? (Stochastic/non-stochastic)

What aspects need to be taken into account in establishing a level of biological concern ?

Background doses

- dose assessment for natural exposures (particularly α emitters)
- variability

Interaction with chemical effects

How do we take account of interactions between species

If an appropriate degree of protection is applied, will it be possible to detect any 'harm' against natural background variability, the influence of background radiation and other natural and anthropogenic stressors ?

What do sustainability and biodiversity mean in terms of measureable endpoints ?

Future priorities ?

INTERNATIONAL ATOMIC ENERGY AGENCY
Department of Nuclear Safety, Division of Radiation and Waste Safety

Specialists' Meeting on
Protection of the Environment from the Effects of
Ionizing Radiation: International Perspectives
(Reference: 723-J9-SP-1114.2)

Quantities, Units and Compliance Working Group

Panel: Per Strand (Leader), Dennis Woodhead, Steve Domotor, Rodolfo Avila

Examples of issues to be addressed:

Identification of relevant target organisms

Applicability of a generic reference organism approach

Dosimetric models - for acute/chronic exposures

- taking account of relative biological effectiveness

What are the implications of and methods for taking account of deficiency of data on the distribution of radionuclides external to and within organisms ?

To what extent are environmental methods and parameters, used for the protection of man, appropriate in an environmental protection context ?

Should limiting criteria be specified in terms of dose or concentration ?

Putting together a quantitative framework for protection
Issues:

- Spatial averaging – taking account of patchy contamination and definition of affected population;
- Time averaging – implications of the life span, seasonality, hibernation

Are present environmental risk analysis methodologies unrealistically quantitative ?

Future priorities ?

Summary of endpoints and analysis of their relevance on the basis of certain criteria

X, relevant; (X), may be relevant; ?, of uncertain relevance; –, irrelevant

END-POINT	**RELEVANCE CRITERION**									
	Sustainability	**Indicator**	**Ecological significance**	**Measurable**	**Predictable**	**Compliance**	**Societal relevance**	**Comparison**	**Aggregation**	**Research need**
Mechanistic effects	(X)[1]	X	?	X	?	–	(X)[2]	X	X	X
Deterministic effects	X	X?[3]	X	X	X	X	X	X	?[4]	X
Stochastic effects[5]	X	–	?	–	–	–	X	X	X	X
Concentrations & Doses[6]	X X	X	 X	X	X X	X	X X	X[7] X[7]	 X	 X

[1] Mechanistic effects were considered to be connected to sustainability, although at the present more in a precautionary context.
[2] Public concern may not be strong over non-observable effects; however concern over risk for possible genetic effects is strong
[3] The relevance of deterministic effects as indicators in the "early warning" sense is limited, since observation of such effects indicate that the objective of protecing the environment has probably failed, depending on the criteria adopted.
[4] Aggregation of determinsitic effects, either reulting from the same type of harm, or from different types of harm, may be difficult because of different dose-response and dose-effect relationships.
[5] Cancer risk for humans may presently be the most relevant stochastic endpoint. Hereditary effects are also relevant, and in this representation are grouped under Mecahanuistic effects.
[6] Concentrations and doses are interdependent; either aspect of environmental radioactivity may be particularly relevant to certain criteria.
[7] Both concentrations and doses may be of particular relevance fo comparisons with background (natural) levels.

Criteria applied in Table above

- Sustainability: This may be considered the ultimate goal of all efforts to protect the environment (including human health). In view of the complexity of this criterion, the relevance of a certain endpoint to sustainability may not be easy to assess. Nevertheless, for the purpose of this exercise, the group included sustainability in the criteria for assessing relevance of endpoints.
- Indicator: A certain endpoint may serve as early warning or stand in a quantifiable relationship to the risk of environmental harm.
- Ecological significance: Different endpoints may have different meanings and implications or relevance in a site- (ecosystem-) specific context.
- Measurable: Endpoints may differ in the ease with which they can be measured.
- Predictability: For potential exposures, i.e. resulting from accidents or from a release from a waste repository in the far future, endpoints are of course not measurable. The justification of endpoints can, however, also be based their predictability in, e.g., performance assessments.
- Compliance: Certain endpoints may be of greater interest than others for judging, or demonstrating, compliance.
- Societal, etc. relevance: Endpoints may be selected on the basis of their relevance to local and regional, economic, cultural and public concerns.
- Comparative aspects: Certain endpoints may be of high relevance for comparisons with the impacts of other environmental hazards.
- Aggregation: Additive for various sources of a similar kind (including background), and possibly also for non-radiological hazards.